Dynamics of ecosystem services driven by changes in land-use intensity in mountains

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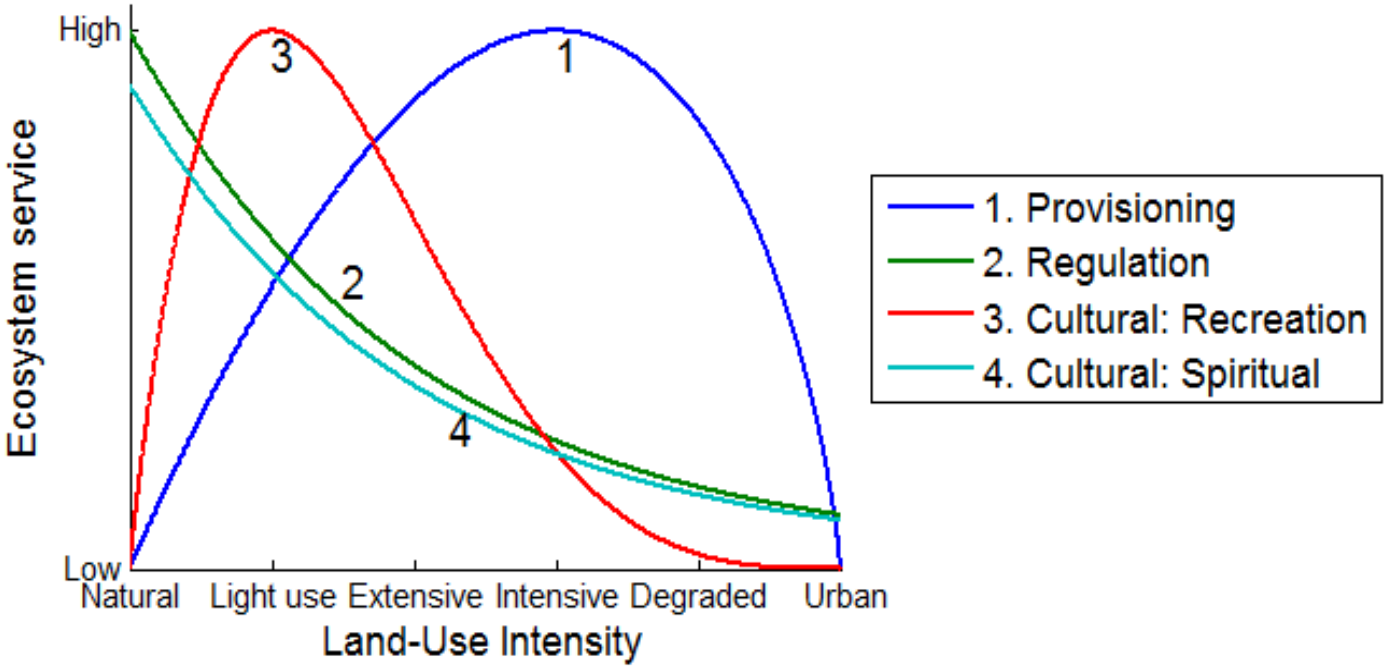
ES dynamics and land intensification

- Tradeoffs between ES occur in space and time (Anderson et al., 2009; Raudsepp-Hearne et al., 2010)
- Understanding temporal dimension of multiple ES in a landscape (Bennett et al., 2009)

- Land intensification
  - A major change in land management in the last 50 years
  - Rapid increases in agricultural yields but decreases in biodiversity (Lambin et al., 2000)
  - Major consequences on ES (Tscharntke et al., 2005)
  - Knowledge is still limited on these consequences (Swift et al., 2004)

Stylized models

- Previous stylized models of ES supply as a function of land management
  - applied in global or regional ES assessments (Burkhard et al., 2009; Schneiders et al., 2012)
- Example (by Braat and Ten Brink, 2008 and De Groot et al., 2010)
  - variations of four types of ES
  - along gradient of land-use intensity with 6 classes

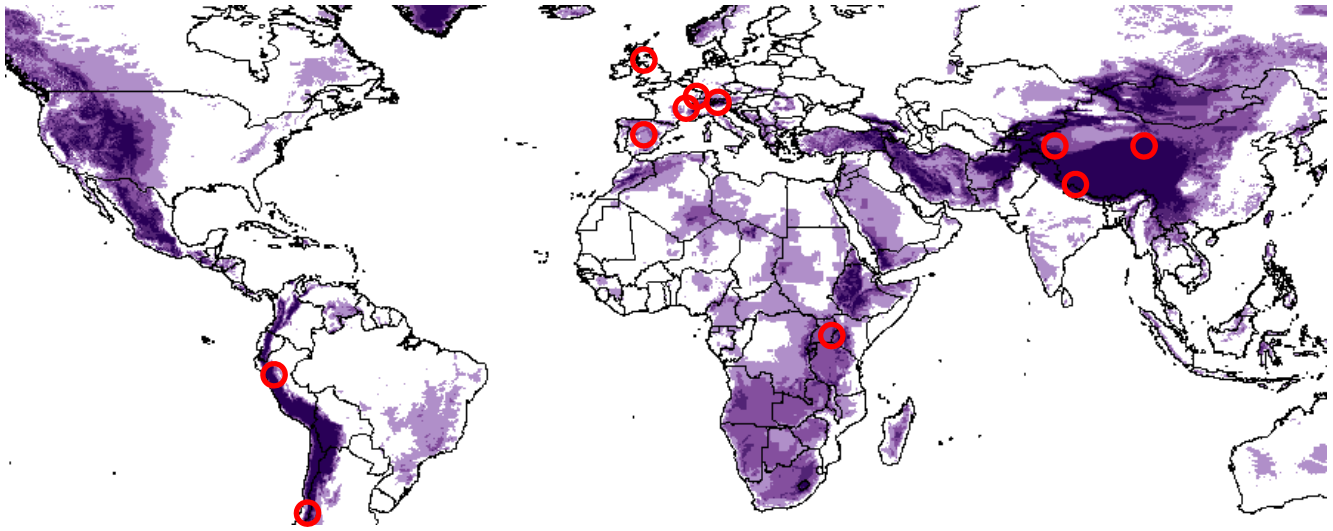


Objective

- Analyzing how temporal changes in land-use intensity influence the supply of multiple ES and the tradeoffs among them, using mountain landscapes as examples
  - review case studies of ecosystem services dynamics in mountain landscapes
  - summarize their findings in a stylized model of ES supply and tradeoffs along a gradient of land-use intensity

Method

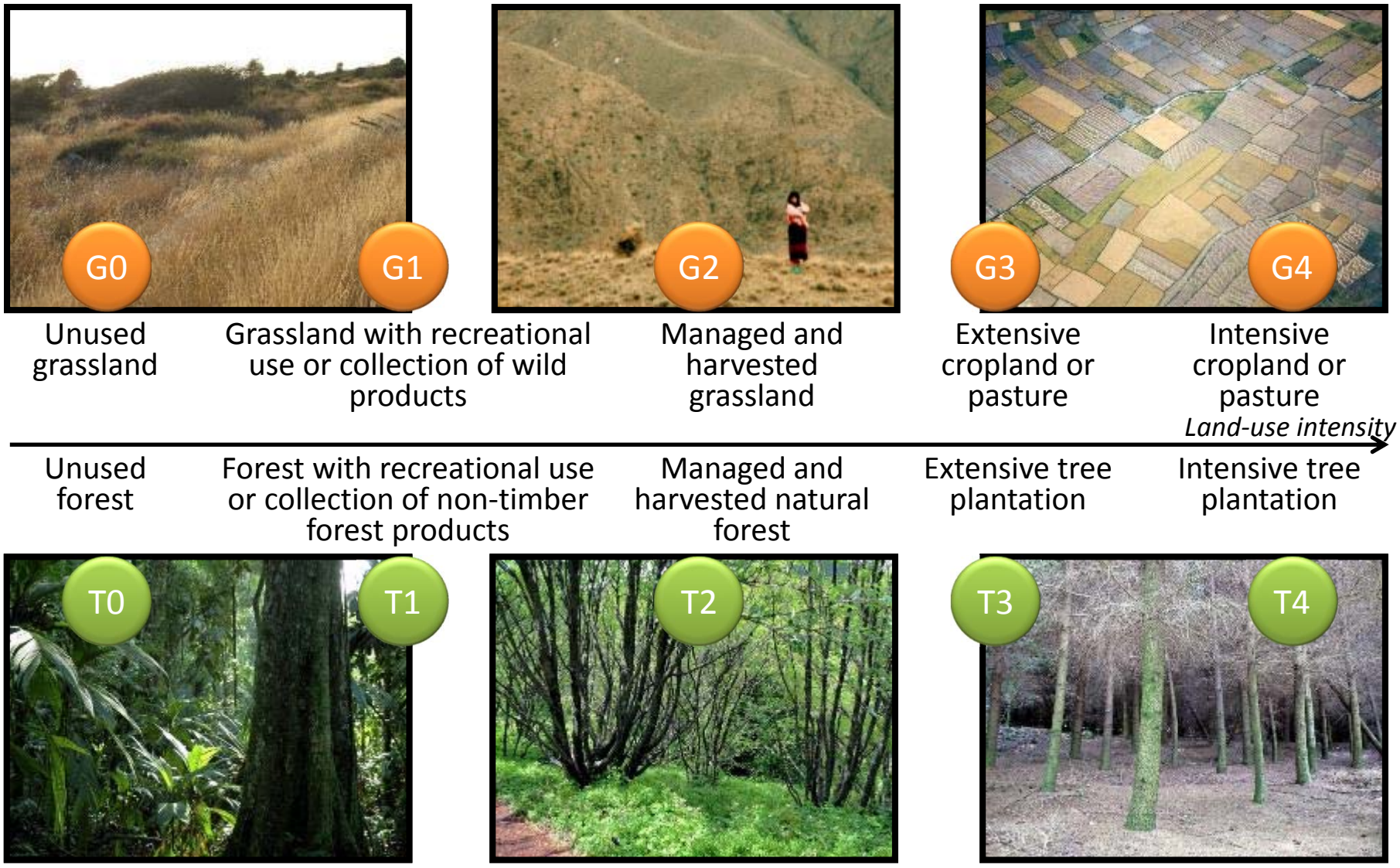
- Search in ISI Web of Knowledge
  - papers quantifying multiple ecosystem services
  - in mountainous landscapes
  - at two or more times.
- Only 18 selected publications, after rejecting studies with:
  - No quantitative data,
  - No described land-use change,
  - Small spatial scales (e.g. forest plot)
  - One single ecosystem service



A typology of land uses needed for comparing cases.

Differentiation between land uses dominated either by trees or grass

(as in de Groot et al., 2010)

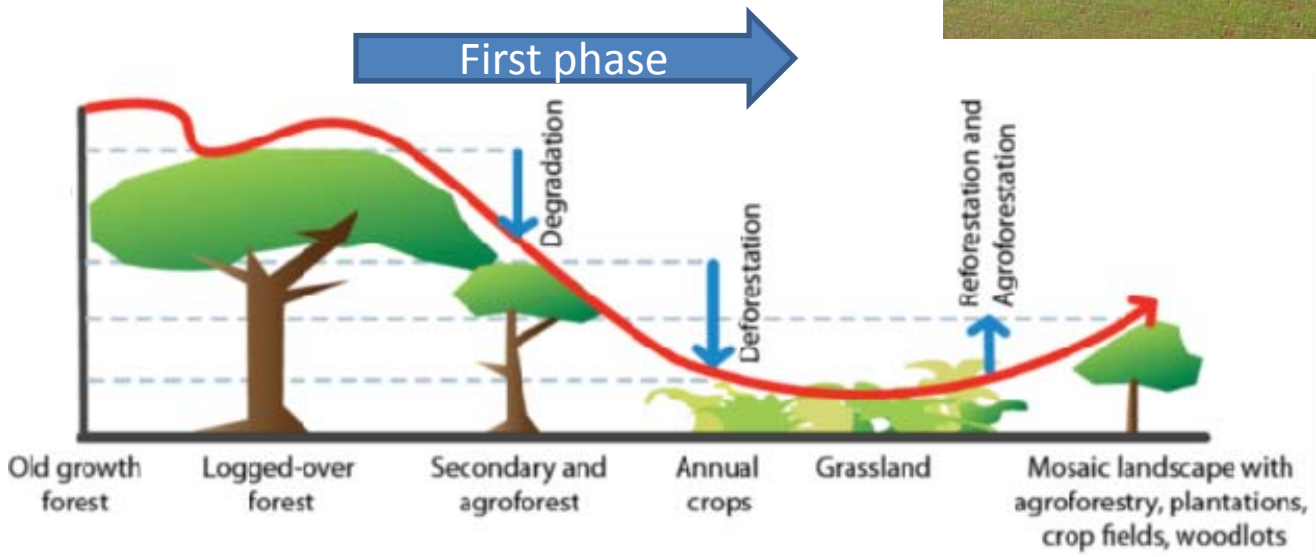


Results

- Case studies classified into 3 groups of land intensification ("stories")
  - Story 1: Agricultural intensification (n=4)
  - Story 2: Forest intensification (n=3)
  - Story 3: Extensification (n=11)
- The stories reported similar temporal dynamics in ES

Story 1: Agricultural intensification

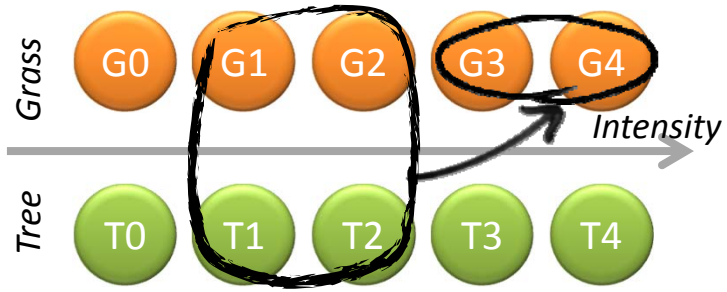
- Conversion of natural or semi-natural ecosystems to croplands or pastures
- Often driven by food demand
- Often in developing countries
- Similar to the first phase of the forest transition framework
- “Agricultural frontiers”



Story 1: Agricultural intensification

Agricultural intensification

Temporal evolution of land-use intensity

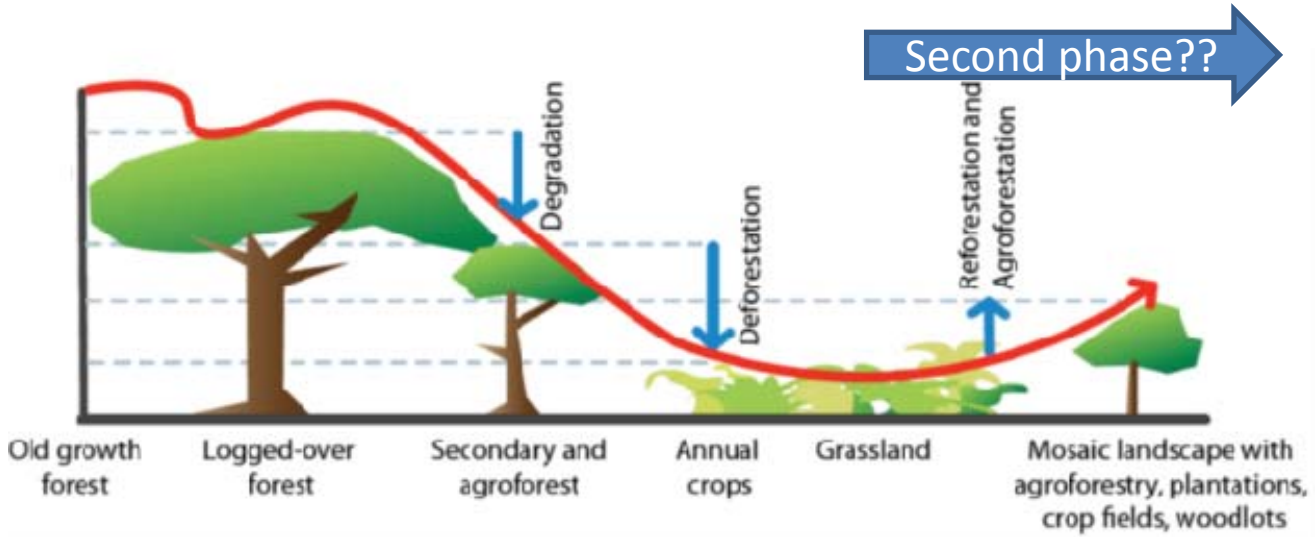


Temporal evolution of ecosystem services

↑ Food	↓ Timber
↓ Other prod	↓ Soil, water
↓ Carbon	? Spiritual
? Recreation	? Heritage

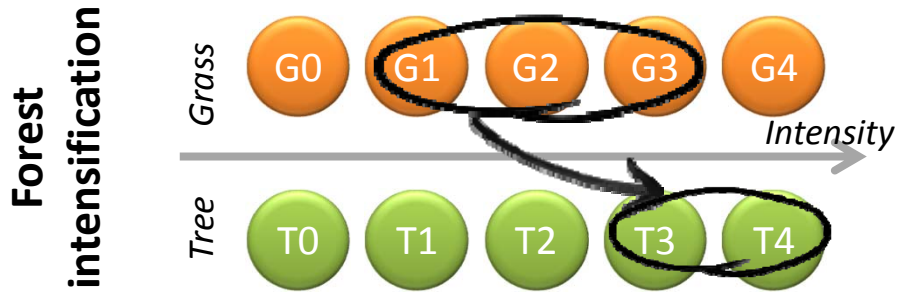
Story 2: Forest intensification

- Expansion of forest plantations, often intensively managed
- Examples in Chile, Ecuador, China
- Drivers: forest or environmental policies, wood market, carbon demand



Story 2: Forest intensification

Temporal evolution of land-use intensity



Temporal evolution of ecosystem services

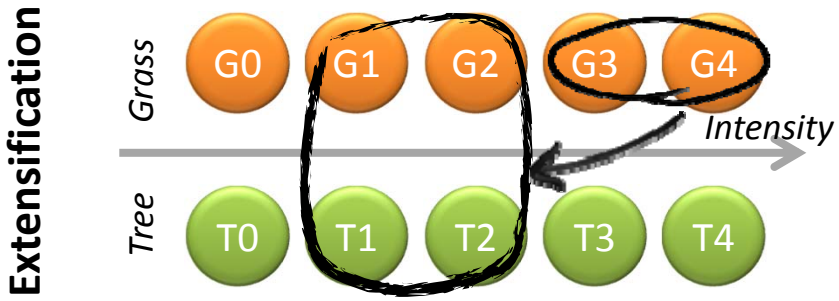
↓ Food	↑ Timber
? Other prod	↓ **Soil, water**
↑ Carbon	? Spiritual
? Recreation	? Heritage

Story 3: Extensification

- Abandonment, rewilding and transformation to multifunctional landscapes
- Drivers: More demand for regulation and cultural services (water, recreation, landscape beauty), less demand for food (agricultural and trade policies)
- Mostly in industrialized countries

Story 3: Extensification

Temporal evolution of land-use intensity



Temporal evolution of ecosystem services

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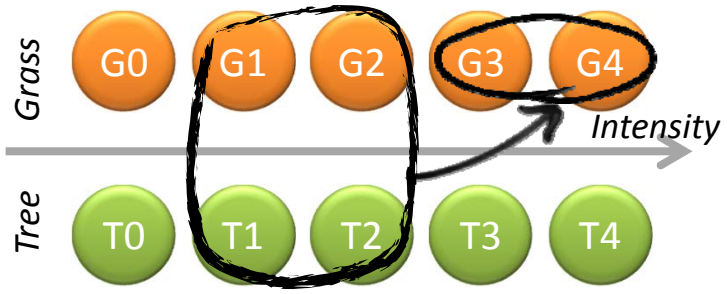
Temporal evolution of land-use intensity

Temporal evolution of ecosystem services

Agricultural intensification



↑ Food
↓ Other prod
↓ Carbon
? Recreation
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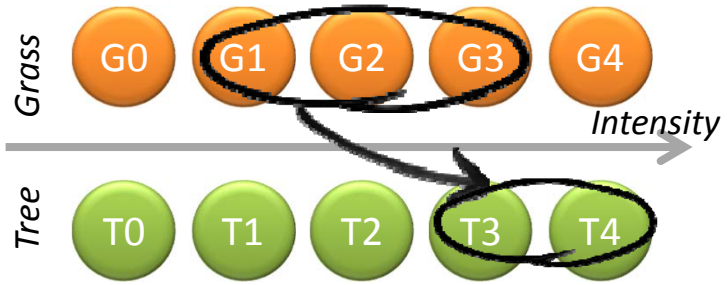
? Spiritual
? Heritage

Forest intensification



↓ Food
? Other prod
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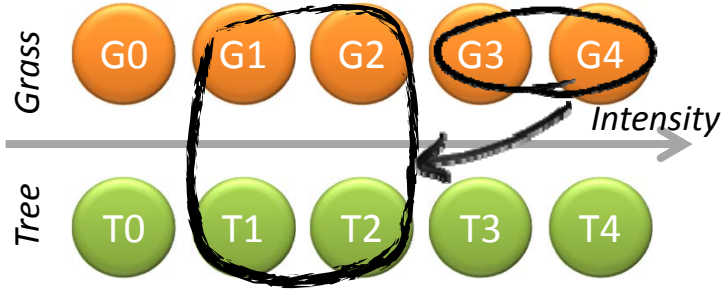
Extensification



↓ Food
? Other prod
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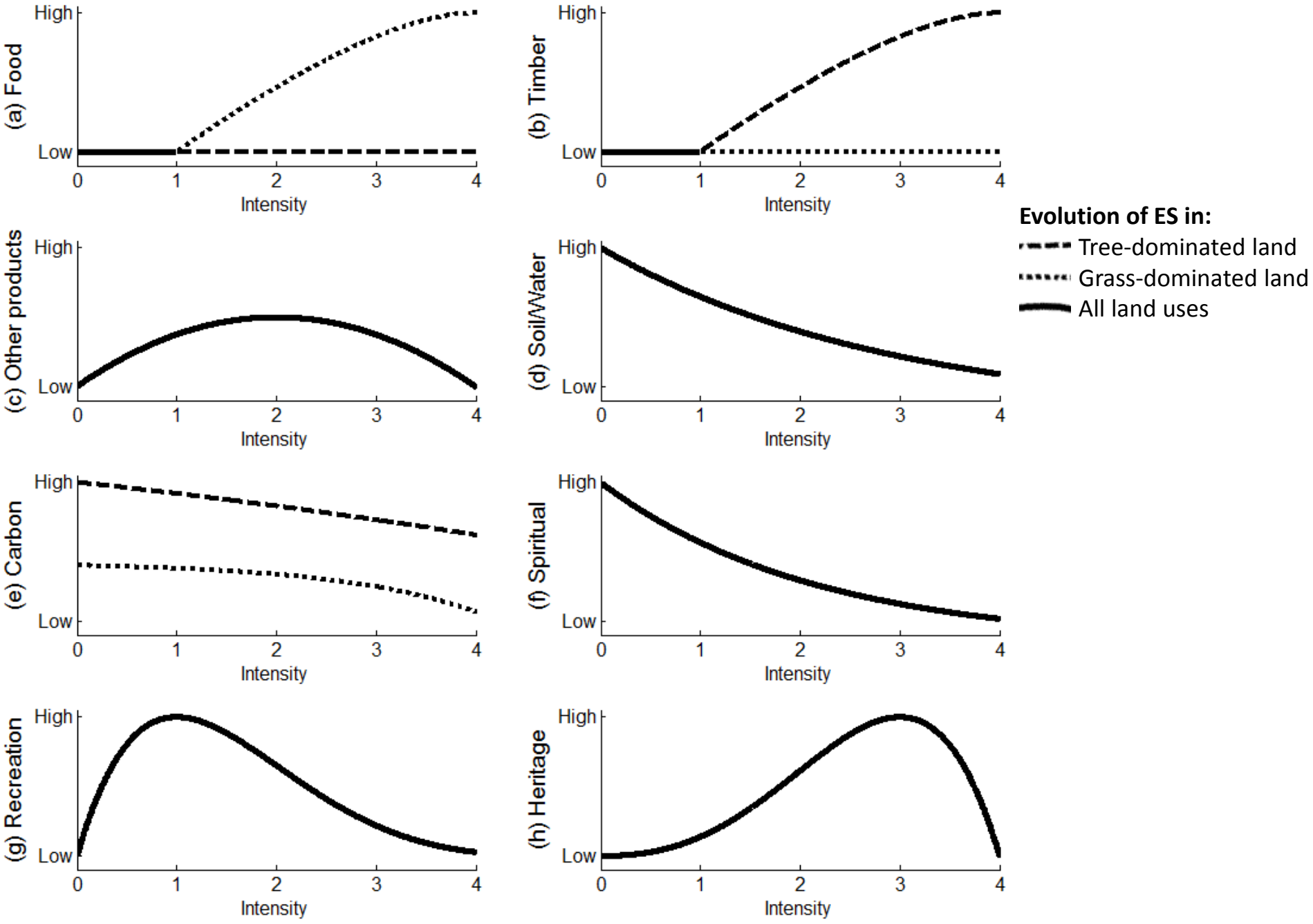
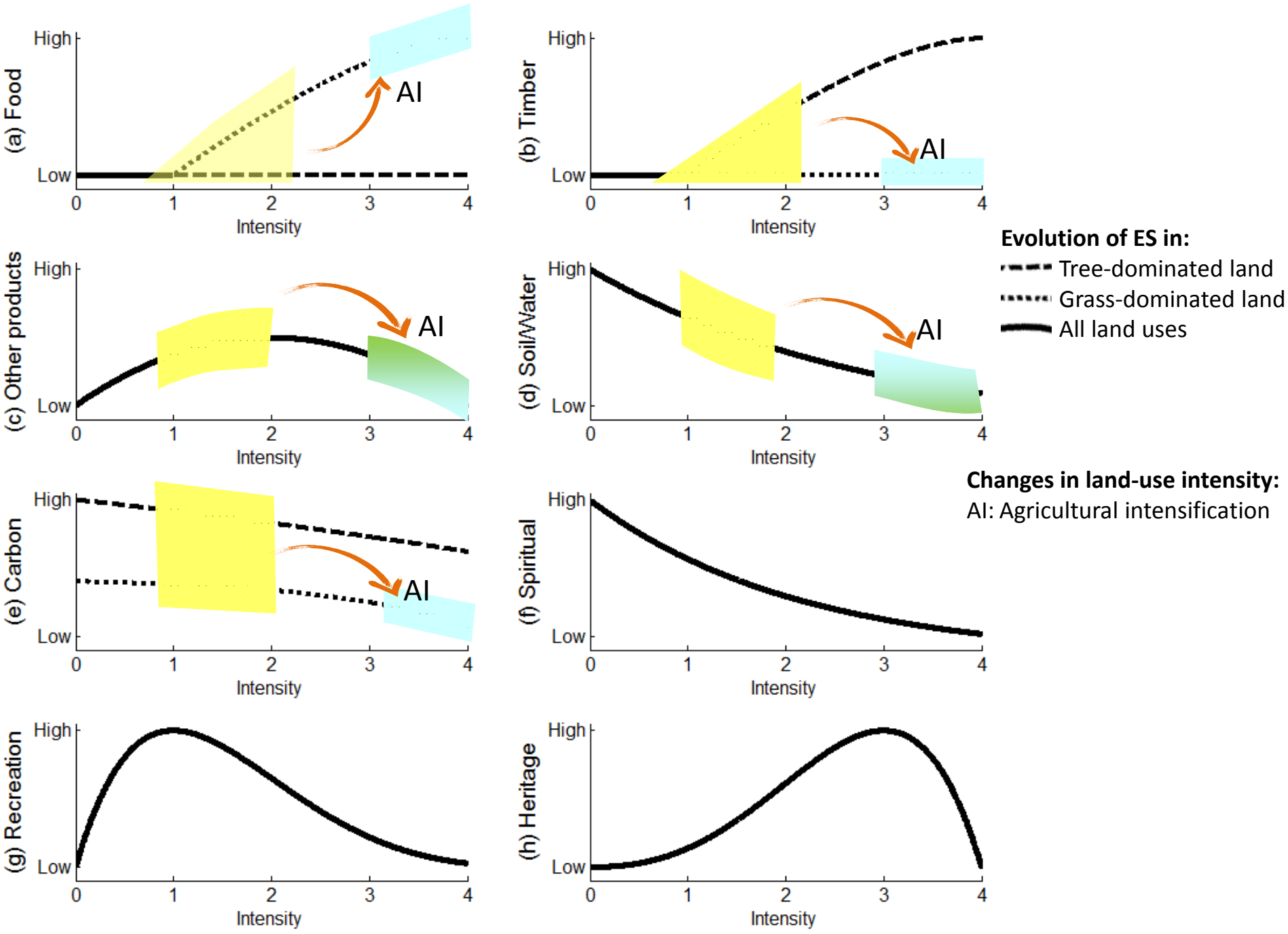
↓? Heritage


(a) Food
(b) Timber
(c) Other products
(d) Soil/Water
(e) Carbon
(f) Spiritual
(g) Recreation
(h) Heritage
High
Low
0
1
2
3
4
Intensity
Evolution of ES in:
Tree-dominated land
Grass-dominated land
All land uses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Intensity
AI
Evolution of ES in:
Tree-dominated land
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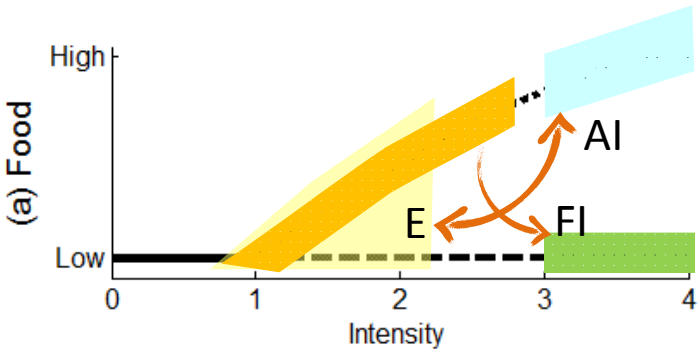
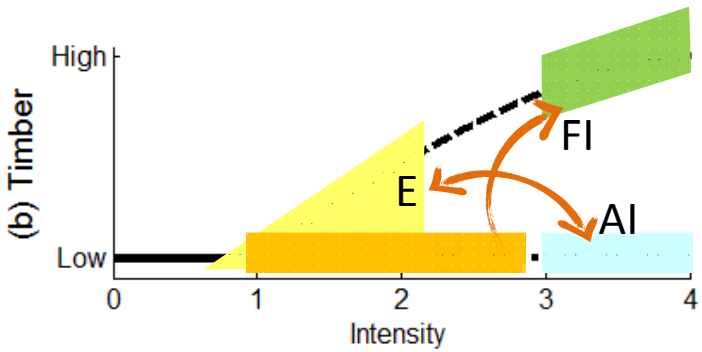
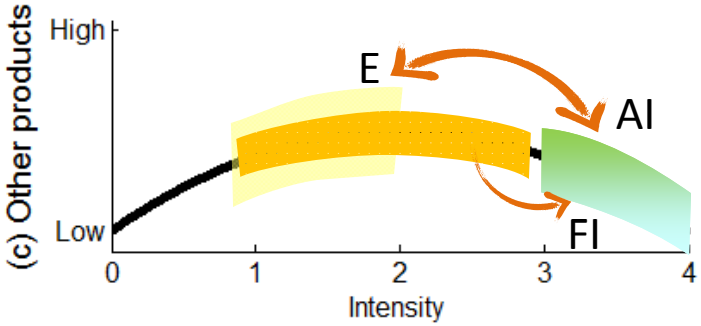
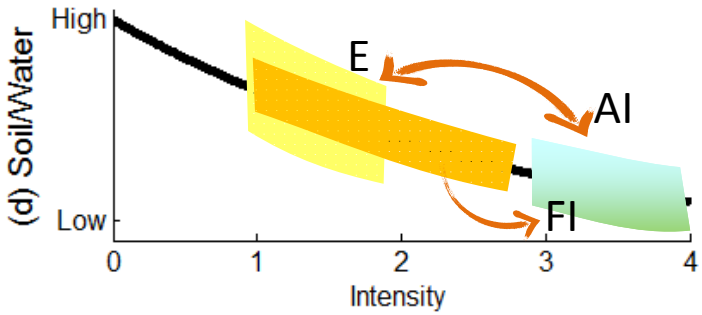
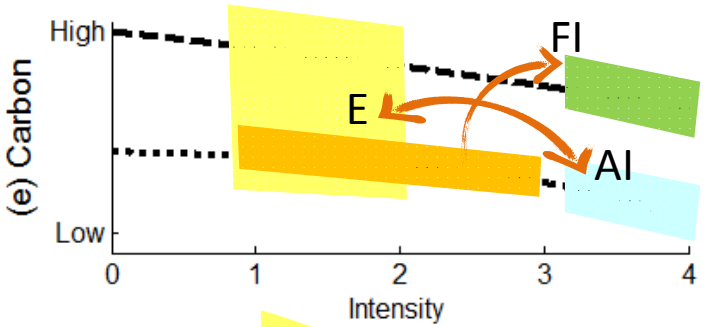
All land uses
Changes in land-use intensity:
AI: Agricultural intensification

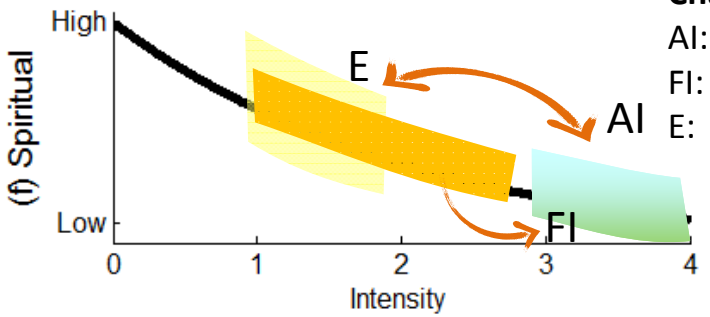


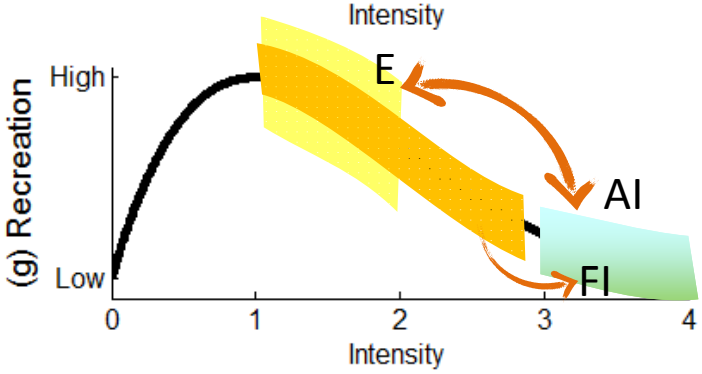


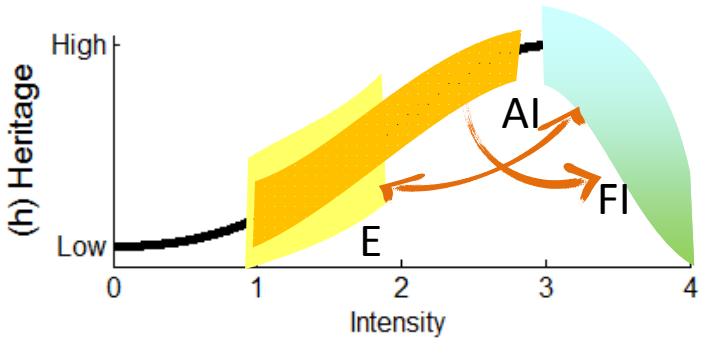












Evolution of ES in:

- Tree-dominated land
- Grass-dominated land
- All land uses

Changes in land-use intensity:

AI: Agricultural intensification
FI: Forest intensification
E: Extensification

Conclusions

- Most common trade-offs:
  - Increases in desired ES following intensification (food or timber) and declines in other ES
- Limitations
  - Few studies, diverse approaches, different ES
- Simple stylized model
  - Can be used in global modeling works
  - Communication tool on trade-offs
  - Starting point in specific studies: what explains divergence from the simple model?
  - Could be tested in non-mountain areas
- Issue of scale and landscape heterogeneity
  - E.g., agricultural intensification in some places may coincide with, if not encourage, rewilding in others

Thank you!

RESEARCH PROGRAM ON Forests, Trees and Agroforestry

CGIAR

This research was carried out by CIFOR as part of the CGIAR Research Program on Forests, Trees and Agroforestry (CRP-FTA). This collaborative program aims to enhance the management and use of forests, agroforestry and tree genetic resources across the landscape from forests to farms. CIFOR leads CRP-FTA in partnership with Bioversity International, CIRAD, the International Center for Tropical Agriculture and the World Agroforestry Centre.

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